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rabbits, for instance, are such that very sharp images are formed in the periphery. It is necessary to assume therefore that the diminished number of nerve-ends is an additional cause. (2) There is an important modification of the color-sense towards the periphery; at a certain distance blue and yellow only are seen, and farther away no color at all is distinguished. But the changes which colors undergo as they are looked at peripherally are very different from those which are caused by a diminished brightness; red becomes orange when it is looked at with the periphery, but when looked at in a faint light, black; neutral violet becomes blue and gray respectively. Hence a diminished brightness cannot be the cause of the change. (3) That a diminished brightness does not occur on the border is made plain by these experiments. Two black and white rotating disks were looked at, one with the fovea and one with some other portion of the retina, and black was added to the latter until it looked no brighter than the former. A maximum sensibility was found at a distance of  $20^{\circ}$ — $25^{\circ}$  in a horizontal direction, and  $12^{\circ}$ — $15^{\circ}$  in a vertical direction. The increase of sensibility is much greater horizontally than vertically. An interesting fact is that the lower portion of the retina is less sensitive to brightness than the upper portion. We have no occasion to notice slight changes of brightness in the sky, but it is essential to safe moving about that unusual things on the ground should attract our attention.

Kirschmann draws attention to the fact that the cone of light which can enter the pupil from an object far to one side is very thin, and hence that the objective brightness of things seen laterally is diminished in the ratio of the cosine of the angle, if the object is far away. Hence the actual increase in sensibility in the lateral portion of the retina must be greater than the apparent increase by an amount enough to make up for this objective decrease of brightness. After taking account of this, the curve of increase is found to be a straight line. The cause of this greater feeling for brightness in the non-foveal portion of the retina he finds in the supposition that the end-members of the rods, which are much more developed than those of the cones, act as reflecting mirrors to send some light back upon the nerve-terminations. It remains to be found out whether the rods are most numerous at the place where he finds the maximum sensibility.

An interesting fact which appears from his tables, but which Kirschmann himself does not mention, is that for bright objects (the background was constant, 270 black + 90 white) the nasal portion of the retina is decidedly better than the temporal. This is a difference which, as Schön has shown, is of great importance in enabling us to determine whether a given pair of double images belong to an object without or within the horopter—so great that by an artificial alteration in the relative brightness of the images an error of judgment in this respect may be produced. C. L. F.

*Ueber den Lichtsinn der Netzhautperipherie.* TREITEL. Arch. f. Ophth. XXXV, 1, p. 50.

This is the third independent investigation into the sensibility of the lateral portions of the retina that has been made within a very short time, and the difficulty of the subject is apparent from the fact that all three investigators, A. E. Fick, Kirschmann and Treitel, have obtained very different results. Treitel finds the lateral portion less

sensitive than the fovea, Kirschmann finds it more sensitive by about one seventh, and Fick finds it ten to fifteen times more sensitive. The experiments of Fick seem to us to have been conducted with much the most acumen and with the most careful avoidance of sources of error. In the first place, his object was seen by transmitted light, instead of by reflected light. A small piece of porcelain was lighted up from behind, and the amount of light allowed to fall upon it was regulated by a diaphragm. Both the other observers used Masson disks, and measured the amount of white necessary to add to the black to make the disk just perceptible; their source of light was the windows of the room, or the windows somewhat darkened by curtains. But every one knows that it is almost impossible to hold two strips of paper, near together even, in front of several windows, in such a way that they are equally lighted. Kirschmann, it is true, had windows looking upon a gray wall, and allowed for the contrast effect of his background, but neither of these precautions was taken by Treitel. The results of Fick and Kirschmann are not really incongruous, for Kirschmann worked by day-light and Fick in the dark; and even Treitel found that the supposed superiority of the fovea was almost evanescent in a diminished light.

In the second place, it was discovered by Schadow that the presence of a bright image on the fovea renders the lateral parts of the retina much less sensitive than they would be without it. Treitel maintains that it is impossible to steadily fixate a point when there is nothing to look at; that may be so in general, but if there is a bright point above and one below, it is not difficult to keep the eye steady half way between them, and this is the device which Fick made use of. Treitel finds the retina one tenth as sensitive at a distance of thirty to forty degrees from the center in daylight, but half as sensitive in a faint light. The difference he attributes to the more ready fatigue, and hence the slower adaptation of the center. But it has never been shown that the center is more easily fatigued than the periphery. This is really a case of question-begging. It can only be more readily fatigued by being more sensitive, and whether it is more sensitive or not is the very question at issue. A supposed fact is not rendered more probable because it can be explained by something else which is a mere re-statement of the fact itself. Moreover, a common experience shows that the center is less subject to fatigue than the periphery; any one whose eyes have been pained during sickness by the presence of a light in the room knows that it can be much more easily endured by looking directly at it.

On the whole, the subject seems to be left at present in a good deal of confusion. The former observers who agree with Treitel are Rupp, Exner, Dobrowolsky and Gaine, Chodin, and Bull; those who disagree with him are Aubert (but he thinks the adapted eye is about the same throughout), Schadow, Charpentier, and Butz. But the experiments of Fick, as we have already said, seem to us to carry more conviction with them than any of the others.

C. L. F.

*Ueber intermittirende Netzhautreizung.* BELLARMINOW. Arch. f. Ophth. XXXV, 1, p. 25.

Kirschmann has just called attention to the fact that two sensations furnished by a rotating disk are fused into one sensation with less velocity of rotation at the fovea than in the periphery. Bellar-